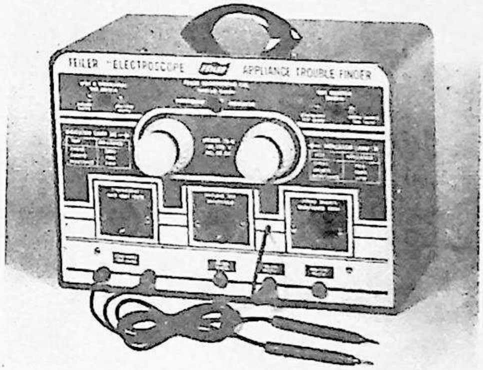
FEILER

ELECTROSCOPE

MODEL TS-8



Operating Instructions

AND

COURSE
IN APPLIANCE REPAIR AND ELECTRICAL SERVICE

FEILER "ELECTROSCOPE" MODEL TS-8

PART I OPERATING INSTRUCTIONS SECTION

(See PART II for Appliance Repair Course)

GENERAL

Your new FEILER "Electroscope" Appliance Trouble-Finder, Model TS-8, is an improved portable test instrument enabling you to quickly and easily test (1) any electrical appliance; (2) all electrical accessories; and (3) all electrical wiring and circuits.

Listed below are just a few of the electrical items that you can test with your FEILER "Electroscope".

(1) Any electrical appliance including:

- Irons
- Electric Clocks
- Toasters
- Fans
- Juicers
- Electric Stoves
- Lamps
- Shavers
- Refrigerators
- Washing Machines
- Ironers
- Air Conditioners
- Vacuum Cleaners
- Heaters
- Waffle Irons
- Signs
- Fluorescent Lights
- Electric Adding Machines
- Electric Typewriters
- Mixers
- Sun and Heat Lamps
- Driers
- Perculators
- Broilers

(2) All electrical accessories including:

- Switches
- Circuit Breakers
- Flashers
- Fuses
- Outlets
- Sockets
- Plugs
- Receptacles
- Condensers
- Selenoids
- Relays
- Electromagnets
- Bulbs
- Transformers
- Ballasts
- Resistors
- Cords
- Thermostats
- Theostats
- Fluorescent Starters
- Motor Coils

(3) All electrical circuits and wiring for:

- Opens
- Shorts
- Intermittents
- Grounds
- Resistance
- Leakage
- Voltage
- Current
- Continuity

(4) And in ADDITION, all motors including:

- Single Phase
- Multi-Phase
- Universal
- Squirrel Cage
- Induction Motors
- Fractional Horse-Power

As new appliances become available to the general public, you will find that they, too, can be quickly and easily tested with your FEILER "Electroscope". The unique new "shunt-power" lamp-indicator principle employed in your "Electroscope" is in accordance with the approved test procedures recommended by leading appliance manufacturers.

TECHNICAL SPECIFICATIONS

POWER: Operates from 95-125 volts, AC or DC, 25-60 cycles. 32 volt and 220 volt appliances may be tested by means of the continuity tester built into the TS-8 "Electroscope".

DIMENSIONS: Case measurements--8" high, 6" deep and 11½" long. Indicator lamps extend 1½" beyond 6" depth and carrying handle extends 1½" above 8" height.

WEIGHT: 10 lbs., complete.

HOW TO OPERATE YOUR "ELECTROSCOPE"

(Refer to Front Panel of Instrument
for location of switches, receptacles,
etc.)

OPENS, SHORTS AND RESISTANCE CHECKS: To test an appliance for an open, short, or for correct resistance, first determine the wattage rating of the appliance to be tested. Place the plug extending from the panel of the TS-8 (immediately beneath indicator lamp B) into the appropriate jack on the lower right of the panel. These jacks are labeled "10-100 Watts"; "100-400 Watts"; and "400-1500 Watts". If the appliance has a wattage rating that is included in more than one jack rating, always place it into the higher rated jack. For example, to test an appliance rated at 100 watts, place the plug into the jack labeled "100-400 Watts". If the appliance rating is unknown, always place the plug into the highest rated jack, "400-1500 Watts", and then reduce to a lower rated jack if the test is unsatisfactory.

After the wattage rating of the appliance has been determined and the wattage selector plug has been placed in the correct jack, the "Test Selector Switch" (located on the upper right hand corner of the panel) should be placed in the "Opens, Shorts, Resistance Tests" position. This is accomplished by sliding the switch to the right. The appliance may then be plugged into the receptacle labeled "Opens, Shorts, Resistance Tests".

Plug the "Electroscope" into an outlet which supplies correct operating power for the appliance under test. Turn on the appliance which is to be tested. If the appliance is shorted, then Indicator Lamp (A) will glow with full brilliance and Indicator Lamp (B) will not glow at all. If the appliance under test is open, then Indicator Lamp (A) will not glow and Indicator Lamp (B) will glow with full brilliance. If the appliance is operating correctly, it will have some amount of resistance and both Indicator Lamps (A) and (B) will glow with some amount of brilliance. The exact amount of brilliance of each lamp will depend upon the resistance of the appliance under test. For example, if the appliance has a wattage rating of 500 watts, then Indicator Lamp (B) will glow slightly brighter than Indicator Lamp (A). This is a good method of checking the appliance for proper resistance. Assume that an appliance with a wattage rating of 500 watts is under test. As previously outlined, Indicator Lamp (B) should glow brighter than Indicator Lamp (A). If this condicion does not exist and Indicator Lamp (A) glows with more brilliance than Indicator Lamp (B), then the appliance probably has a lesser resistance than it should and is defective. However, before making a final conclusion that the appliance is defective, it is best to complete all of the tests outlined in this section, and it would be to the advantage of the service man to check the section on Heat Appliances in Part II, "Fundamentals of Appliance Repair."

CONTINUITY CHECKS: To make a continuity check on any electrical item, place the tip plugs on the test leads into the jacks labeled "Continuity Test Leads". Place the "Test Selector Switch" (on the upper right hand corner of the panel) in the extreme left position labeled "Continuity Test Leads". Plug the "Electroscope" into any available source of power, 95-125 volts AC or DC, 25-60 cycles.

To make a continuity test, use the test leads and place one test lead tip on one side of the circuit (such as appliance cord) and place the other test lead on the other side of the circuit. Continuity will be indicated by both Indicator Lamps (A) and (B) lighting. The brilliance here will be the same in both lamps, but the brilliance of the two lamps will indicate to a certain degree the amount of resistance in a circuit. This, however, is comparative only and for greater accuracy the "Opens, Shorts and Resistance Test" should be made.

GROUND TESTS: To test appliances or circuits for grounds, the "Test Selector Switch" should be in the "Continuity Test Leads" position and the test leads inserted into the "Continuity Test Leads" jacks. The appliance is then plugged into the receptacle labeled "Ground Test Receptacle" and the line cord of the "Electroscope" plugged into an outlet which supplies correct operating power for the appliance.

The appliance is then touched first with one test lead and then with the other. If the appliance is grounded, both Indicator Lamps (A) and (B) will glow. (If both test leads are touched to the appliance at the same time, the lamps will glow but this will NOT indicate a grounded condition.) Only one test lead at a time should be touched to the appliance, never both.

THERMOSTAT AND HEAT TESTS: Certain appliances, such as irons, have built-in thermostats which regulate the flow of current to the iron heating element to control the temperature. To check the operation of the thermostat, plug the cord of the appliance into the receptacle labeled "Thermostat and Heat Tests". Place the switch in the upper left hand corner of the panel to the extreme left. This switch is labeled "Heat and Thermostat Test Switch" and the extreme left position is the "800-1350 watts" position. ALWAYS place this switch in this position and then, if a lower range is necessary, the switch can be placed in the "350-800 Watts" position. Plug the cord can be placed in the "350-800 Watts" position. Plug the cord of the "Electroscope" into an outlet which supplies correct operating power for the appliance. In the center of the panel there is a red jewel labeled "Thermostat Indicator". When the appliance is heating, this indicator will glow red. When the appliance is cooling, this indicator will not glow at all. This will indicate that the appliance thermostat is operating correctly.

NOTE: This test, although entirely satisfactory for most purposes, does not indicate the DEGREE of heat that the thermostat is cutting in and out of the heating circuit. For this purpose, the use of the FEILER Temperature Pyrometer, Model TS-8-TP, is recommended. Complete details on the pyrometer can be obtained by writing the FEILER Engineering Company.

While operating your "Electroscope" on high wattage appliances which are SHORT CIRCUITED, you may find that the case becomes quite warm. This condition will exist if the time duration of the test is very long. Although not harmful, prolonged tests on SHORTED high-wattage appliances are not recommended. It is suggested that when testing high wattage appliances which are SHORTED, that the service man make the test, shut off the appliance, and proceed with the other tests. (This precaution is necessary ONLY with those high wattage appliances which are SHORTED). Do not prolong unless necessary.

TESTS FOR PRESENCE OF VOLTAGE IN A CIRCUIT: When checking house wiring or other electrical circuits, it is often desired to determine whether a voltage is present or whether the wiring is "dead". This is particularly true after a switch, fuse, or similar device has just been installed, and you wish to check it for correct operation. You can do this quickly with your "Electroscope". Simply plug the line cord of your TS-8 into the line you are testing. Push the "Test Selector Switch" to the position marked "Continuity Test Leads". Touch together the tips on the ends of the test leads. If a voltage is present, Indicator Lamps (A) and (B) will both light.

If you are testing for voltage at the open ends of a line (or at a fuse box or junction box) instead of at a receptacle, proceed as follows: first, connect together (with a short piece of wire or with your screwdriver) the two prongs of the male plug at the end of the line cord on the TS-8; second, push the "Test Selector Switch" to position marked "Continuity Test Leads". Then, touch the tips of the continuity test leads of the TS-8 to the circuit you are testing. If a voltage is present, both indicator Lamps (A) and (B) will light.

You may test for the presence of any voltage, either AC or DC, from 32 volts up to and including 220 volts, using the methods just described. On lower voltages (in vicinity of 32 volts) Indicator Lamps (A) and (B) will light with low brilliance. If greater brilliance is needed, remove either one of the Indicator Lamps (but not both) and screw in any ordinary 10 amps. house fuse in place of lamp.

On voltages over 125 volts BE SURE THAT BOTH INDICATOR LAMPS ARE USED. Both lamps will glow with full brilliance when testing 220 volt circuits.

There are many additional tests that can be performed with your FEILER "Electroscope" which have not been outlined here. For example, use the "Opens, Shorts and Resistance" test procedure for reducing the voltage applied to a solder pot or soldering iron, until ready for use. In addition, the thermostat and heat test can be used to check an appliance for intermittent operation. Many of these tests can be found in detail in Part II, "Fundamentals of Appliance Repair"

PART II

BASIC COURSE IN THE FUNDAMENTALS OF ELECTRICAL APPLIANCE REPAIR

GENERAL

Electrical Appliances are devices designed to operate from alternating current (AC) only, or direct current (DC) only, or from both AC or DC. In general, they perform a function which eases, speeds-up, and simplifies work in the home, shop, and office. The repair of these appliances generally is performed in the field, and the efficiency and speed with which you perform these repairs depends upon proper parts and procedures. In addition, probably the most important requirement of all is adequate, reliable testing devices. It is with this thought in mind that the manufacturer of your FEILER "Electroscope" has prepared for your benefit this informative, simplified course in the fundamentals of appliance repair. We urge you to study it carefully and keep it handy on your bench. You will find it an invaluable reference manual which you can use to assist you while performing actual bench repairs.

Most appliances fall into one of three main groups regardless of the work they perform:

1. A resistance element which produces heat.
2. A motor which causes rotation of a shaft, blade, gear, cam, or similar device.
3. A device which provides light rays for visibility or acts as a source of special rays (such as ultra-violet or infra-red).

If the service man understands the operation of each of the three basic methods, and is capable of recognizing the method in use in an appliance, servicing the appliance becomes mainly a matter of making the proper tests and then using common sense to effect the simple mechanical repair usually required.

RECOMMENDED TOOLS

The servicing of electrical appliances, fortunately, requires a minimum of tool equipment, and, therefore, tools generally represent a very small investment on the part of the service man. The use of the FEILER "Electroscope" will permit you to reduce the inventory of required tools even further, so that the only ones needed are those ordinary hand tools which almost every man has in his home tool box. Following is a representative list of the simple tools needed to service practically any electrical appliance or circuit:

7 inch long-nose pliers
6 inch screw driver
4 inch crescent wrench
Pocket knife
100 watt soldering iron
Oil can with light oil
"Electroscope" Tester with Test Leads.

Additional tools may be obtained _if_ _and_ _when_ definite specialized requirements should arise for their use. In the majority of repair jobs, however, the tools listed above will more than suffice.

One of the important steps in any repair job is a careful thorough cleaning of the appliance before returning it to the customer. When customers remark, "Why, it looks just like new," you can be assured that their satisfaction will reach their friends, and as a result, you will find an increase in your business. No. 00 steel wool is excellent for cleaning discolored chrome-plated appliances if care is taken not to scratch the finish. The use of a good grade of polishing compound for brass, aluminum or chrome will improve the appearance of any appliance, and is well worth the investment.

HEAT APPLIANCES

Principle of Operation. The principle of operation of all heat appliances containing a resistance element is the same, viz., an electric current flows through a resistance of such value as to allow the element to become heated and thus radiate energy in the form of heat. The general repair procedure, therefore, is to check for correct resistance; and if incorrect, or open-circuited, to locate the cause of the trouble. It must be brought out here that the produced energy is dependent upon the resistance and is greatest when the resistance is the lowest. A 1350 watt electric heater, for example, has less resistance than a 660 watt heater and thus radiates more energy. This is true because the resistance of the 1350 watt heater is lower so as to allow more current to flow through the element. Appliances such as light-bulbs are contained in a vacuum to prevent disintegration of the element due to the great amount of heat. Heat appliances, which glow cherry red to red, do not have to be vacuum enclosed because more of the heat is radiated to perform some useful work and they, therefore, seldom overheat, unless they become defective.

Test Procedure. The first step to take in servicing any appliance, whether heat or otherwise, is to verify or to disprove the customer's complaint. This step should become an automatic procedure performed as soon as the appliance is received. In the case of heat appliances, the greatest number of complaints will fall into one of the following general classifications:

1. Will not heat
2. Uneven or low heating
3. Blows fuses
4. Overheats
5. Grounded.

Your FEILER "Electroscope" has been designed to allow you to make the correct tests to locate the cause of the above complaints with the speed and efficiency required of a first-class appliance repair shop.

Thermostats. Many heat appliances contain a thermostat that controls the heat of the appliance, or rather, maintains the heat at a fairly constant temperature. A great deal of the trouble found in heat appliances will be centralized in the thermostat circuit. Because the operation of thermostats varies with the type of appliance, repair procedure for thermostats will be found in the instructions given for each appliance, but in general, all thermostats operate on the same basic principle. They are constructed of one or more metal strips whose physical shapes vary with the amount of electric current that flows through them. These strips are known as "bi-metal strips", and one end of the strip usually has a contact point which opens or closes the electrical circuit to the resistance element. A simplified circuit is shown below.

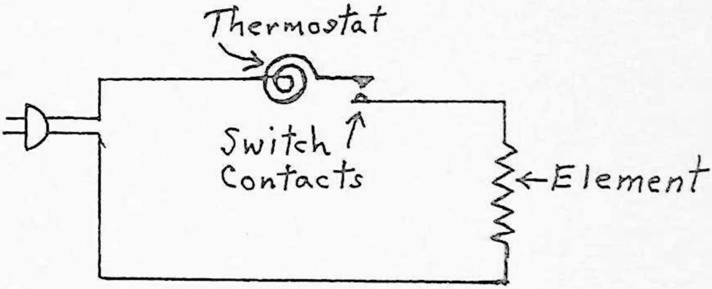


Figure I.

When the electric power is applied to the circuit, the thermostat-switch is in the closed position. There is a circuit from one side of the line plug, through the thermostat, then through the switch, and finally through the resistance element back to the other side of the line plug.

As the element reaches correct operating temperature, the shape of the thermostat changes in such a way as to open the switch contacts which in turn open the electrical circuit to the element. As the element cools, the thermostat cools also, and once again its shape changes so as to close the switch contacts. This procedure repeats itself over and over again; the current to the element is turned on and off; this action, in turn, keeps the heat radiated by the element at a nearly constant temperature.

In some cases, the tension of the bi-metal strip is variable by means of a knob. This permits the temperature of the appliance to be varied to suit the required needs. Most flat irons have a knob of this kind. In other cases, the thermostat is used to light a bulb or open a spring device to indicate to the user that the work being done is finished, as in the case of pop-up toasters and waffle irons.

Testing--Will Not Heat. Plug the appliance into the FEILER " Electroscope" and test according to the procedure outlined in Part I, page 2, " Opens, Shorts, and Resistance Checks". If the appliance tests "open", remove the appliance power cord and check for continuity. (Repair procedure for all appliance cords can be found in the section of this course on electrical accessories, page 22). In the event the appliance contains a thermostat, further checking by means of continuity tests on the "Electroscope" must be made in order to localize the trouble to either the appliance element or the thermostat. If the appliance is fused, (as some electric percolators are), the fuse should be checked for a possible "open" also. Use the continuity test leads here to determine the condition of fuse.

Testing--Uneven or Low Heating. This complaint is usually caused by excessive resistance within the appliance--either in the appliance cord, cord connector, thermostat contacts, or the connections to the element itself. A careful visual inspection of all connections will usually show up the trouble. A check on the power consumption can be made here using the procedure outlined in Part I, page 2, "Opens, Shorts and Resistance Checks". If the appliance is rated at 600 watts and it is found that it is operating at considerably less wattage, there is definitely a high resistance connection.

Testing--Blows Fuses. In most cases of this type, the appliance is grounded or has a direct "short". It would be best to check the operating conditions first, however.

If the "Electroscope" test on "Opens, Shorts and Resistance" proves that the appliance is operating correctly, the user undoubtedly is overloading the circuit on which the appliance is operating, thus blowing fuses. Complete disassembly and point to point continuity tests (using the continuity test leads on your "Electroscope") will locate the source of difficulty if a short exists in the appliance.

Testing--Overheats. This generally indicates a partially shorted element or improperly adjusted thermostat, with the greatest majority of causes falling into the latter classification. Make the "thermostat and heat" test outlined in Part I, page 4, to verify this condition.

Testing--Grounded. The complaint here will usually be: "I get a shock whenever I handle the appliance" or "Every time I use it, it blows fuses." This will be the result if any part of the electrical circuit is in contact with any part of the appliance outer-case housing. Use the continuity test to verify this. Localize by disassembly and continuity test.

Electric Flat-Irons. Due to the large number of manufacturers and the many different types of irons in use today, it would be impractical to attempt to describe here the exact detailed procedure to follow when servicing every make of flat iron. Since the main differences between different makes of flat irons are in mechanical construction, we shall give the general electrical characteristics only; these characteristics apply to all flat irons.

One common complaint will be that the iron is operating too hot or too cool for the customer's satisfaction. In many instances, this will be due not to a defect in the iron at all, but due to the ironing speed of the individual. Since it would be impossible to construct an iron to fit all requirements, the manufacturer calibrates the heat-control dial scale on the iron for average needs. In these cases, a simple re-setting of the heat-control knob will eliminate the complaint. For example, if the customer complains that the iron is too cool, an adjustment of the knob so that a greater degree of heat will result for any given fabric setting, will satisfy that particular user's requirements.

Thermostats are, in general, somewhat difficult to repair, and in most cases replacement of the old one with a new thermostat is the fastest and most practical solution. There are those instances, however, where a little fine crocus cloth applied to the contacts of the thermostat will prove sufficient. Thermostat adjustments should not be undertaken by the appliance repair man. If found necessary, due to cost or unavailability of replacement parts, adjustments should be made only with the greatest of care so as not to damage the unit.

Element replacement is easiest in the "cast-in-calrod" type of iron (an iron in which the element is sealed in a metal casting) since the repair consists only of replacing the old calrod unit. If the terminal posts are badly scorched, they can be replaced at low cost, and will usually overcome "low heating" complaints. Elements in the conventional type of iron can be replaced easily, but care must be taken to install the new element making good clean electrical connections and with an exact replacement.

Probably the greatest trouble will be found in the line cord; repair instructions on this will be found in the "Electrical Accessories" section of this manual, page 22.

Toasters. Electric toasters can be divided into three classes: (1) non-automatic (where the toasting time is manually controlled); (2) semi-automatic (where the toasting time is mechanically controlled by a spring-wound mechanism); and (3) automatic (where the timing is by means of a thermostat). Here, as in flat irons, thermostat repair is difficult. The spring-wound mechanisms often become clogged with bread crumbs and cleaning of the gears or other similar parts of the mechanism will usually suffice. Mechanical difficulties can be corrected upon visual inspection.

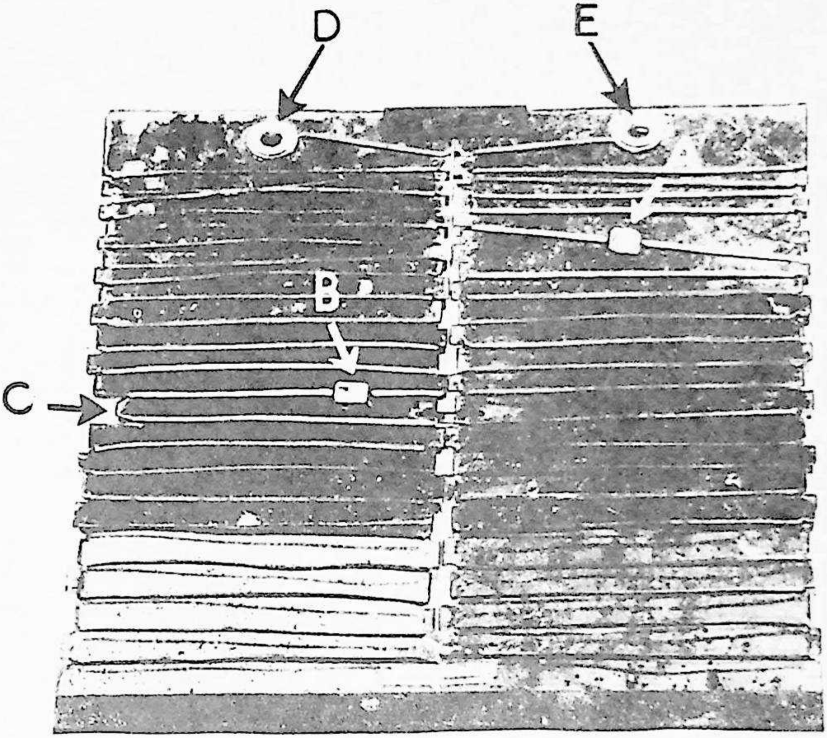


Figure 2.

The elements of toasters can usually be repaired since almost all faults in toaster-elements are due to a break in the winding. Special splicing sleeves can be obtained for this purpose. The broken ends of the element are inserted in the sleeve and the sleeve hammered flat. Figure 2 shows two methods for obtaining extra length for the ends of open elements. Either cut away a small section of the mica insulator as shown by C or unwrap a turn as shown by A.

Electric Stoves and Hot-Plates. The repair procedure here is easy because a thermostat is seldom found in an electric stove. The repair of broken elements is as shown in figure 3, page 15. The splicing sleeve used here is quite similar to the one shown in figure 2. Stretch out the element ends to fit; and hammer the sleeve flat by pounding, holding a metal object on the back of the sleeve.

Heaters. Heaters are usually of the cone type and repair generally consists of replacement of the heater cone element. If it is not of the cone type, the element can be repaired, if broken, by following the same procedure shown in figures 2 or 3, depending upon which applies.

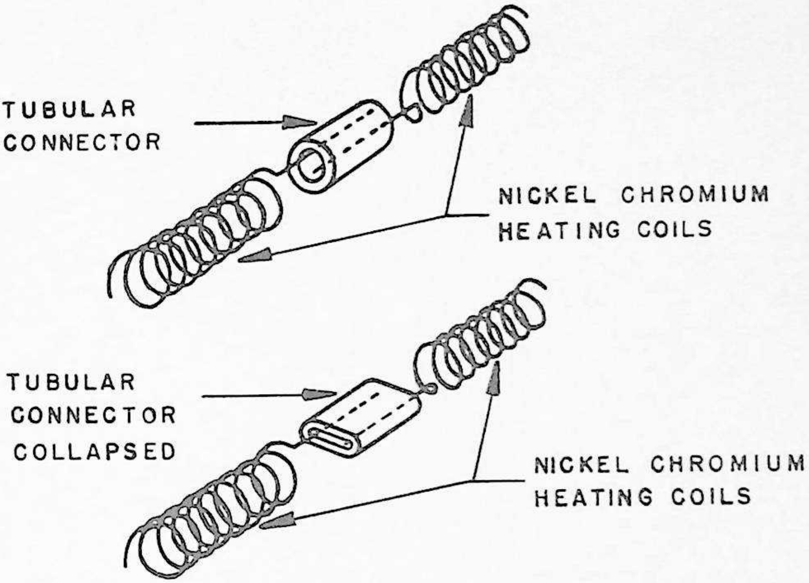

TUBULAR CONNECTOR
NICKEL CHROMIUM HEATING COILS
TUBULAR CONNECTOR COLLAPSED
NICKEL CHROMIUM HEATING COILS

Figure 3.

Waffle Irons. Here, as in electric stoves and heaters, the element can be repaired by the use of a splicing sleeve. Waffle irons usually contain a thermostat, however, and readjustment, cleaning, or replacement may be necessary. The greatest trouble will be found with the cord that connects the upper element to the lower element. It will be necessary to replace this cord entirely if it is found to be badly worn or burned.

Ironers. Electric ironers or manglers present an unusual repair problem because of their construction. Once the cause of the trouble is located, it would be best to analyze the situation as to availability of tools and replacement parts. In some cases, return of the ironers to the manufacturer would be the best course of action. If, on the other hand, the repair consists of cord replacement, the ironer can be repaired with minimum time and cash outlay on the part of the service man.

Driers. Driers fall into two catagories since they contain a motor and an element. (For motor repairs, see section on motor driven appliances). The heating element can be repaired following instructions given for other "heat-type" electrical appliances, such as toasters and electric stoves. When testing driers, however, be sure to isolate the motor from the element circuit so that the test will indicate the exact location of the trouble.

Heating Pads and Electric Blankets. In general, these appliances are the same in operation and control, except that blankets are much larger. The repair of pads and blankets should be made with the greatest of care since a grounded element is dangerous (and could even be fatal in some cases) to its user. Here again, cords, thermostats and switches generally give the greatest amount of trouble and the element the least. Extreme care should be exercised with the thermostat and if there is any indication of faulty opera tion - replace it. Remember, a sleeping person is not aware of the heat that the blanket is giving off and if the thermostat is defective, it could be dangerous.

HOW TO REPAIR MOTOR DRIVEN APPLIANCES

Principle of Operation. The biggest majority of Electrical Motor-Driven Appliances use two types of motors, the universal motor and the split-phase induction motor. The universal motor is used on most vacuum cleaners, egg beaters, mixers, electric shavers, and hand drills. This type of motor gives decreased torque with increased speed. The induction motor is used where the torque must increase with speed; this is the requirement in washing machines, ironers, power tools, etc. Figures 4A and 4B, page 17, show the schematic diagrams of the universal motor, where the armature windings and the field windings are in series.

Figure 5, page 17, shows the split-phase induction motor which consists of two windings known as the starter winding and the running winding.

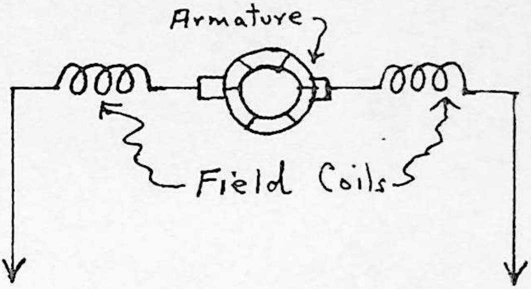


Figure 4A.

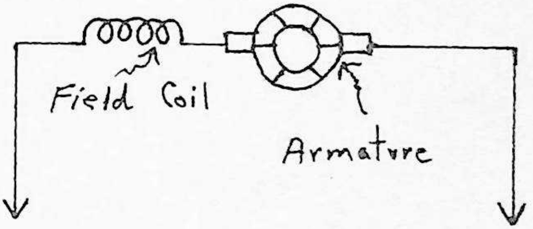


Figure 4B.

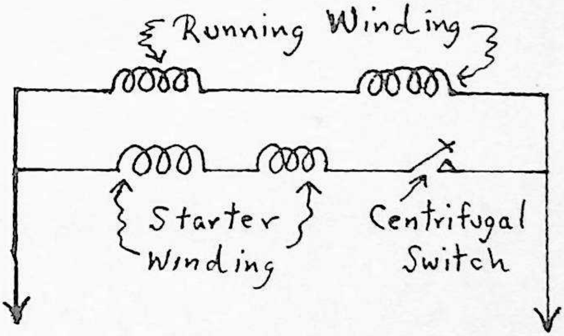


Figure 5.

As the split-phase motor reaches about 90% of full-load speed, the centrifugal switch on the starter winding opens the circuit to the starting winding, and the motor runs on the running winding alone.

Test-Procedure - General. Since the current drawn by the motor, rather than the wattage rating is usually stamped on the nameplates of most motors, the wattage must be calculated. If the current consumption is given, the wattage can be computed quite easily. Simply apply the formula: Watts equals Volts x Current. For example: a motor designed to operate from 120 volts consumes 1.5 amperes. Following our formula, 120 x 1.5 equals 180 watts. Remember that this is the wattage consumed while the motor is operating under normal conditions of load and speed. When the wattage rating has been determined, the "Opens, Shorts, Resistance" checks can be made with your FEILER "Electroscope" test set. Continuity checks are, in general, the best to make on any motor since you can test point to point. In this manner, the exact cause of the trouble can be centralized to a certain component or group of components, facilitating easy repair.

Test Procedure - Universal Motors. First--look for broken, dirty or worn brushes. Loose brush springs and dirty commutators are often causes of trouble--so check these, too. Brushes must seat properly and conform to the curvature of the commutator. Excessive oil, grease and dirt will slow down a motor below its operating speed; so cleaning a motor will nearly always improve performance. Carbon tetrachloride is best as a motor cleaning agent. Fine crocus cloth is best for the commutator segments as it leaves no grit deposit. Carbon "Tet" can be obtained at any drug store. Crocus cloth is available at all hardware stores. After you have made the visual tests just described, make the following tests. The motor must be disconnected from the wall-outlet for these tests.

Using the continuity test leads on your FEILER "Electroscope" test set, and following the procedure given for continuity checks, touch one test lead to either brush holder on the motor. Touch the other test lead to the remaining brush holder. This will apply a small voltage to the commutator, but none to the field coils. Rotate the motor slowly by hand. Indicator lamps (A) and (B) should flicker evenly. If the lamps go out when the motor is stopped at any position while brushes are resting on a commutator segment only, you have found an open commutator segment. If this is the case, it is usually best to replace the commutator.

Test Procedure - Induction Motors. Since the greatest amount of trouble here will be due to open or burned out starter-windings and to defective starter-winding switches, the continuity test is the quickest check to make. The starter-winding can easily be recognized since it is the smallest. If the winding is burned out, send it to a motor shop for rewinding. If the switch is defective, it sometimes can be repaired, but usually it must be replaced. Usually the switch becomes defective and will not open. As a result, the high current continues to flow through the starter winding. The motor does not reach full operating speed, and an excessive load is applied to the motor. This increases the current through the starter winding and it finally burns out. If the winding is open, always check the starter switch, too.

Repair Procedure - All Motor-Driven Appliances. Practically all motor-driven appliances can be repaired following the instructions contained in the above three test procedures. Remember that dirt is the greatest cause of trouble; and that a complete, thorough cleaning job is necessary.

If the appliance contains a gear box or an agitator, check for worn or stripped gears. Oiling and greasing are especially important here. Most gear boxes use S. A. E. 20 motor oil as a lubricant. Use a good grade if refilling is found necessary. Always check motors for "grounds" to motor frame since these can be most hazardous. This is especially true in washing machines.

HOW TO REPAIR LIGHTING APPLIANCES

Note: The fluorescent lamp is becoming increasingly popular and repair jobs for the appliance repair-man are becoming more frequent as each day goes by. In view of this fact, most of this section will be devoted to fluorescent lamps. Since a majority of the troubles found in sun and heat lamps are covered in the "Electrical Accessories" section, refer to that section for cord repair and for socket and switch repairs.

Principles of Operation. The fluorescent lamp operates on the principle that an inert gas will radiate energy in the form of high frequency radiations when ionization takes place. At each end of the lamp there is an electrode and across these electrodes a high voltage is applied. Due to the low pressure of the gas, the high voltage arcs across the lamp. This sets up ionization of the gas, and a high frequency radiation of energy excites the inner coating of the tube. This coating is fluorescent, and consequently radiates light when excited by these high frequency waves. The circuit diagram of most fluorescent lamps is shown below:

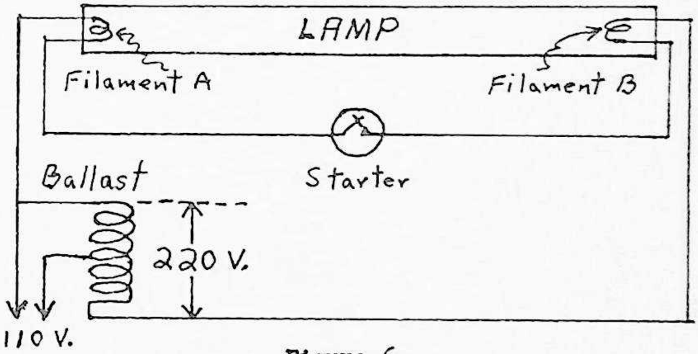


Figure 6.

The circuit can be traced in the following manner: From one side of the line through Filament "A", through the closed contacts of the starter, up through Filament "B" and down to the ballast. The circuit is completed through the ballast and back to the other side of the line. The action of the ballast is in accordance with the principle that a transformer with poor efficiency and regulation will have a large voltage build-up when very little current is drawn from it but will deliver little or no build-up when a large current flows through it.

At the instant that the switch is closed, the current path is as described above. Due to the comparatively high current drain, the ballast has practically no voltage step-up. The filaments glow and become hot, thus heating the gas in the tube. The current flowing through the starter heats a bi-metal strip, and at the peak point of the voltage and current this strip changes its physical shape and opens the contacts. This shuts off the current through the filaments.

The opening of the contacts allows a large voltage to be developed across the ballast since there is now very little current drain. This large voltage flashes across the space inside the bulb and between the two filaments. The filaments are now acting as electrodes instead of heaters, which permit the voltage to ionize the heated gas. The ionization of the heated gas causes radiation of very high frequency waves that excite the inner coating of fluorescent material, radiating light.

The lamps come in various sizes and combinations of tubes, but they all work on the same principle. The only exception is the " Instant-Starting" type of fixtures which are usually found only in stores and offices. The Instant-Start lamp does not contain a starter, nor do the filaments glow. The filaments of the tube act only as electrodes, and the ballast delivers a much larger amount of voltage.

The greatest source of trouble in fluorescent light circuits will be with starters. However, they can be replaced easily and at low cost. Be sure to obtain the correct starter for the wattage rating of the tube in use. The ballast will sometimes hum quite loudly and, although occasionally it can be quieted by tightening the screws securing the ballast to the lamp housing. the only certain cure is to replace the ballast.

Tube replacement should be made when the ends of the tube become black or when they flicker badly. Sometimes, when the tube flickers and the fixture contains more than one lamp, switching the lamps will stop the flickering. This is a temporary expedient at best, and you should explain to the customer that you are doing it only to allow them to obtain a little more life from the tube. It will eventually have to be replaced.

HOW TO REPAIR ELECTRICAL ACCESSORIES

Cord Sets. Due to the wear and abuse that line cords receive, they are by far the most frequent items which become defective. Cords account for the greatest majority of trouble in electrical appliances. The plug end and the appliance end require the most amount of care. Cords seldom become defective in their middle sections. The plug end is the same in almost all instances, but the appliance end varies with the type of appliance.

Cord sets usually fail at the point of greatest flexing or at the plug. The cause of failure at the plug is generally due to jerking which has strained the wire or loosened the screws. Repair can be effected by cutting off a small section of the cord four to six inches back from the plug; make certain that you have removed any strained wire. Next cut back the braid or insulation being careful not to damage any of the wire strands.

In a wall-plug pass the wire through the hole and wrap around the prongs. The wire should be twisted under the binding screws in a clockwise direction so that the wire will not squeeze out as the screws are tightened, as illustrated in figure 7.

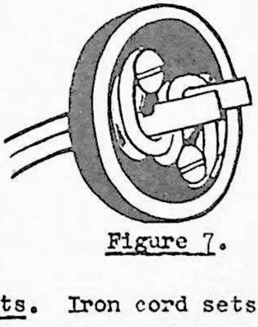


Figure 7.

Iron Cord Sets. Iron cord sets usually fail where the strain relief bushing ends. This is the point of greatest flexing, see figure 8. To repair, cut off the cord six to eight inches back, and then slide the strain relief bushing up the cord, see figure 9. The braid should be cut back sufficiently far to gain the necessary wire to reinstall it in the particular iron. The asbestos roving is thus exposed, see figure 10.

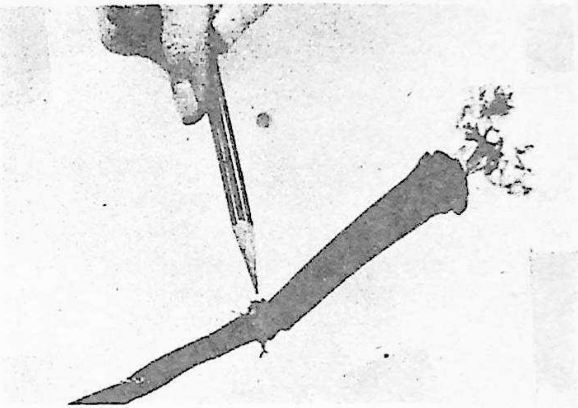


Figure 8.

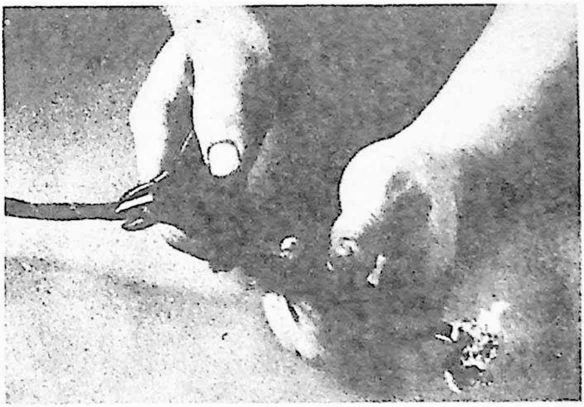


Figure 9.

As illustrated in figure 11, the asbestos roving should be wrapped with thread to prevent particles of asbestos from getting into the iron and interfering with the thermostat operation. The old strain relief clip should be installed on the repaired cord. Do not forget to place the small asbestos pad underneath the clip when replacing it around the cord.

NOTE: The asbestos insulation should be removed far enough back to allow the wires to be twisted around themselves after being wrapped around the terminal screw, see figure 12, page 25. Always wrap the wire around the screw in a clockwise direction as this will ease starting the screw and prevent the wire from squeezing out as the screw is tightened.

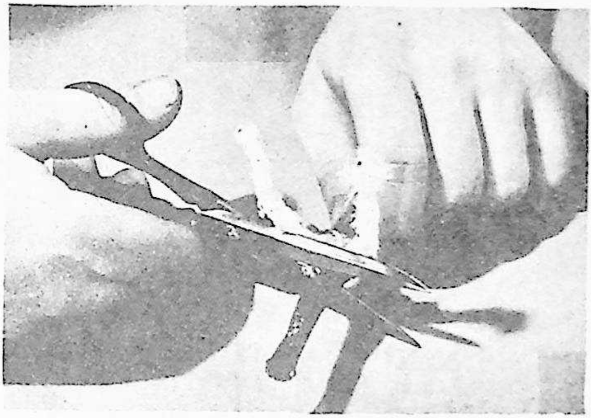


Figure 10.

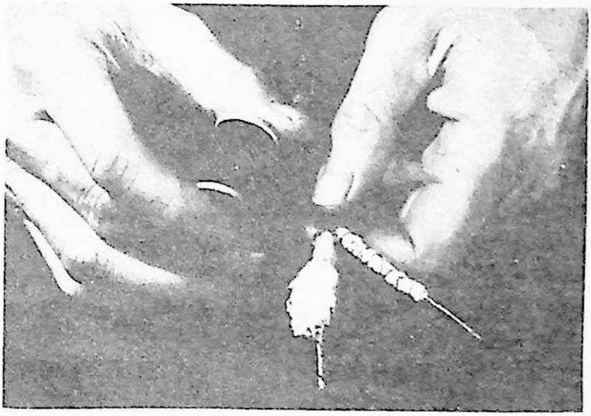


Figure 11.

It is possible also to repair cords broken at other points when shortening is not practical. In such cases the broken section should be determined and cut out. The two ends should be cut back in the manner previously described. Twist the wire to prevent loose wire strands, and then twist each wire around the other to make a firm mechanical joint. This joint should then be soldered and taped -- first each joint separately and then both together.

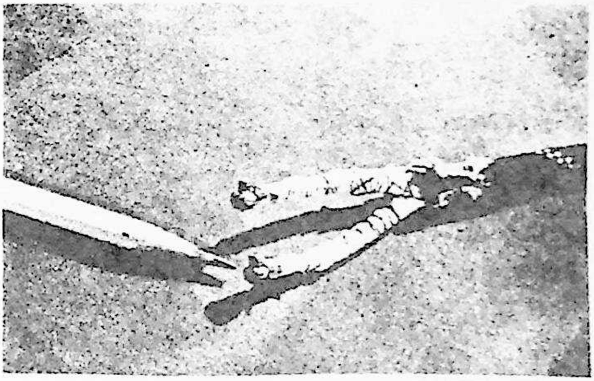


Figure 12.

You may wish to remind your customers of the following points regarding the use of cord sets:

1. Never jerk a cord from an outlet.
2. Never wrap a cord around a hot appliance.
3. Never tie knots in the cord.
4. Do not hang a cord over just one nail or hook.
5. It is dangerous to use frayed or damaged cord.

Testing for Shorts, Grounds, Voltage, Current, etc. To test for shorts or opens, use the procedure outlined in Section I, page 4 -- "Continuity Checks". Check for grounds by using the same procedure except that you ground one of the test leads to an outlet box, available conduit pipe or water pipe. In the case of appliances with conventional plugs, follow the procedure outlined in Section I, page 4 -- " Ground Tests".

Voltage can be tested by comparing the brilliance of the indicator lamps. For example, when testing 110 volts, each lamp glows at half brilliance because they are in series. When testing 220 volts, each lamp will glow with full brilliance. (See " Tests for Presence of Voltage in a Circuit", page 5, Section I, for further details.)

Current can be checked by using the procedure outlined in the "Opens, Shorts, and Resistance Tests," Section I, page 2. This will give a reasonably accurate estimate of the current consumption of the unit under test.

GETTING STARTED IN BUSINESS

If you are located in a small community, you will find that many appliance stores will be willing to "farm out" their appliance repair jobs. Establish yourself with your friends, put up a small sign and if possible, have circulars printed and distributed in your neighborhood. Many of your calls will be in the field--that is, in the home. Your personal appearance is important and although you will be subjected to many "dirty" jobs, you will find that keeping your appearance presentable at all times will prove worthwhile in the long run.

Operating from your basement, attic, or spare room, will help to keep down your overhead, and seldom detracts from your ability to do good work. Many people believe that a good show (modern store, bright lights, etc.) is an indication of good work. This is true enough when the craftsman has been in business many years. You will find that your good work will build for you a name that no fancy "front" could ever do.

After you have acquired the necessary tools, you are ready to go. As you use your FEILER "Electroscope", you will find more and more ways of doing things in addition to those covered in this course. However, since no one course or even all courses can cover every possible fault in electrical devices--a great deal of emphasis must be placed on your use of every-day common sense.

In addition, the manufacturers and distributors are always willing to assist in solving special or "tough" service problems concerning the electrical products which they make and sell. Get acquainted with your local electrical jobber--he can supply you with much helpful information--and also can supply repair parts needed by you on the service jobs.